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Memristive nanostructures based on 2D crystals

Gennady N Panin[1,2]
[1]IMT RAS, Russia
[2]Dongguk University, South Korea

Statement of the Problem: Memristive systems based on two-dimensional (2D) crystals such as graphene, graphene oxide, molybdenum disulphide, etc., 1-5, are considered as a new type of electronic elements with extremely low energy consumption and with ultra-high scalability for processing and storage of information. The unique electronic and optical properties of 2D crystals demonstrate the enormous potential for creating ultra-high density nano-and bioelectronics for innovative imaging systems. The purpose of this study is to develop memristors with a floating photogate so-called photomemristors2,3 based on graphene and nanocrystals.

Findings: A new concept of the formation of self-assembled nanoscale photomemristive heterojunctions of graphene, graphene oxide and zinc oxide in the form of two-terminal memristors with a floating photogate for bioelectronics and optoelectronics is demonstrated.

Methodology & Theoretical Orientation: Photocatalytic oxidation of graphene with nanocrystals of zinc oxide is proposed as an effective method of creating two-dimensional memristive systems with photoresistive switching for synaptic nonvolatile memory of ultrahigh density.

Conclusion & Significance: Two-dimensional photomemristive systems with a floating photogate exhibit multiple states controlled in a wide range of electromagnetic radiation, and can be used as neurohybrid systems for neuromorphological calculations, image processing, and pattern recognition needed to create artificial intelligence.

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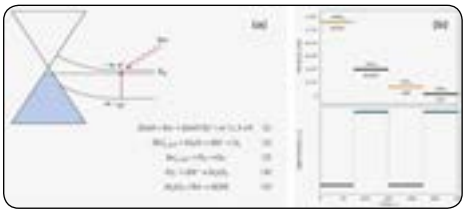

Figure 1: a - Schematic electronic diagram of the G/ZnO NP interface under UV irradiation. Electron-hole pairs generated in ZnO (3.3 eV) under UV irradiation (reaction 1) are separated by a built-in electric field at the G/ZnO NP interface, providing a flow of holes into the graphene; b - resistive states of the G/GO photomemristor, which are switched by the Set/Reset voltage of -3.8/3.3 V in the dark and -3.5/4 V with light pulses and read at 2.5 V.

Recent Publications:

1. Gennady N. Panin et al (2011) Resistive Switching in Al/Graphene Oxide/Al Structure. Jpn. J. Appl. Phys. 50:070110
2. Olesya O. Kapitanova, Gennady N. Panin et al (2017) Formation of Self-Assembled Nanoscale Graphene/Graphene Oxide Photo-memristive Heterojunctions using Photocatalytic Oxidation. Nanotechnology 28:204005.
3. Wei Wang, Gennady N. Panin et al (2016) MoS2 memristor with photoresistive switching. Scientific Reports 6:31224.

4. Wei Wang, Olesya O. Kapitanova, Pugazhendi Ilanchezhiyan, Sixing Xi, Gennady N. Panin, Dejun Fu, Tae Won Kang (2018) Self-assembled MoS2/rGO nanocomposites with tunable UV-IR absorption. RSC Advances 8:2410.
5. Xiao Fu, P. Ilanchezhiyan,a G. Mohan Kumar, Hak Dong Cho, Lei Zhang, A. Sattar Chan, Dong J. Lee, Gennady N. Panin and Tae Won Kang (2017) Tunable UV-visible absorption of SnS2 layered quantum dots produced by liquid phase exfoliation. Nanoscale 9:1820.

Biography

Gennady N. Panin (Ph.D.) is a professor at the Academy of Nanotechnologies (NITA), the Department of Physics at Dongguk University and a senior research fellow at the Institute of Microelectronic Technology of the Russian Academy of Sciences (IMT RAS). He graduated from the Moscow National University with a degree in Applied Physics and Electronics with honors and received his doctorate in physics of semiconductors and solid state electronics at the IMT RAS in 1994. He worked as a research fellow at the Institute of Solid State Physics, Halle, Germany, in 1986 and at the Faculty of Physics of Materials at the University of Complutense, Madrid, Spain, in 1994-1996 and as a research professor (2000-2008), Professor (2008-2017), Vice-Director (2012-2017) of QSRC at Dongguk University, Seoul. His research interests include the physics of quantum structures and multifunctional nanomaterials based on layered multiferroics and graphene to create new photonic and electronic devices for use in nano-information technologies.

g_panin@dongguk.edu
panin@iptm.ru

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